HUC 11010207 – Spring River
Water body IDs: 3203, 3980, and 5003
Pollutant(s): Metals

=-

Total Maximum Daily Load
Implementation Strategies

for

Center Creek (WBID 3203), Center Creek tributary (WBID 5003), Bens Branch (WBID 3980)

Impairments: Dissolved and Sediment Cadmium, Lead, and Zinc

Prepared by:
Missouri Department of Natural Resources
Division of Environmental Quality
Water Protection Program
Watershed Protection Section, TMDL/Modeling Unit
James VeVerka, Environmental Program Analyst

April 22, 2022

WATER BODY SUMMARY

Total Maximum Daily Loads (TMDL) for Center Creek, Center Creek tributary, and Bens Branch

Pollutants: Sediment and Dissolved Cadmium, Lead, and Zinc

Water Body Identification Number (WBID) and Hydrologic Class:
Center Creek WBID 3203 – Class P
Center Creek tributary WBID 5003 – Class C
Bens Branch WBID 3980 – Class C

Location of watershed in Missouri

***Location:** Near Joplin in Jasper County, MO

8-digit Hydrologic Unit Code (HUC):
11010207 – Spring River Subbasin

10-digit HUC Watershed
1107020706 – Center Creek

Designated Uses:[1]
Irrigation
Industrial (WBID 3203 only)
Livestock and wildlife protection
Human health protection
Warm water habitat (aquatic life)
Cool water habitat (WBID 3203 only)
Whole body contact recreation category A (WBID 3203 only)
Whole body contact recreation category B (WBIDs 5003 and 3980 only)
Secondary contact recreation

Impaired Use:
Warm water habitat (aquatic life)

Pollutants Identified on the 2020 303(d) List:
Center Creek WBID 3203 – Cadmium and Lead (sediment)
Center Creek tributary WBID 5003 – Cadmium, Lead, and Zinc (water)
Bens Branch WBID 3980 – Cadmium, Lead, and Zinc (sediment); Cadmium and Zinc (water)

Identified Sources on 2020 303(d) List:
Tri-State Mining District, Oronogo/Duenweg Mining Belt, Abandoned mill tailings

Length and Location of Impaired Segment:
Center Creek (3203) – 26.8 miles from Section 14, T28N, R34W to Section 34, T28N, R31W
Center Creek tributary (5003) - 2.7 miles from Mouth to Section 30, T29N, R32W
Bens Branch (3980) - 5.8 miles from Mouth to Section 28, T28N, R32W

[1] For designated uses see 10 CSR 20-7.031(1)(C) and 10 CSR 20-7.031 Table H. Presumed uses are assigned per 10 CSR 20-7.031(2)(A) and (B) and are reflected in the Missouri Use Designation Dataset described at 10 CSR 20-7.031(2)(E).

TABLE OF CONTENTS

1. Introduction

A total maximum daily load (TMDL) identifies water quality problems, possible causes of those problems, and provides targets for restoration. However, actual water quality improvements are often dependent upon voluntary actions and support from local communities and landowners residing within the watershed. This implementation strategy document is a companion to the TMDL report and provides supplemental information describing actions that will help implement the goals established in the TMDL for Center Creek, Center Creek tributary and Bens Branch. The strategies in this document are specifically focused on surface water protection and best management practices (BMPs) to benefit water quality in the Center Creek watershed. The Center Creek watershed includes the 12-digit Hydrologic Unit Code (HUC) watersheds presented in Table 1. The locations of impaired segment of Center Creek, Center Creek tributary, and Bens Branch are presented on Figure 1.

Table 1. 12-digit HUC watersheds which drain into Center Creek.

12-digit HUC	12-digit HUC Name
110702070601	Dry Valley Branch
110702070602	Headwaters Center Creek
110702070603	Jenkins Creek
110702070604	Jones Creek
110702070605	City of Sarcoxie-Center Creek
110702070606	Grove Creek-Center Creek
110702070607	Webb City-Center Creek

The strategies in this document provide a guide for nonpoint source program coordinators, soil and water conservation districts, local governments, permitted entities, regional planning commissions, watershed managers, and citizen groups looking to implement nonpoint source loading reductions to achieve the allocations established in the TMDL for impaired streams in the Center Creek watershed. Reducing current pollutant loading to the allocations established in the TMDL will result in Center Creek, Center Creek Tributary, and Bens Branch attaining its designated warm water habitat use for the protection of aquatic life. In this way, the TMDL serves as a “pollutant diet” for maintaining the environmental health of the stream. Background, watershed information, and specific pollutant loading targets and water quality objectives for Center Creek watershed impaired segments can be found in the TMDL for the Center Creek, Center Creek tributary, and Bens Branch. Additionally, a 2006 TMDL targeting total and dissolved zinc for Turkey and Center Creek maybe referenced for additional watershed information. The Center Creek, Center Creek tributary, and Bens Branch TMDL document is available on the Missouri Department of Natural Resources’ website at dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls.Questions regarding the TMDL may be sent via email to tmdl@dnr.mo.gov or by calling the Department’s Watershed Protection Section at 573-751-5723.

This document is not intended to prescribe nor prohibit any specific practices or technologies for reducing pollutant loading in the impaired water bodies and is not intended to serve as the sole means of remediation and restoration. However, the Department recognizes that technical guidance and support are critical to achieving the goals of any TMDL. Therefore, while the TMDL calculates the maximum pollutant loading that the impaired stream(s) can assimilate and still meet water quality standards, this strategies document provides additional information to assist in watershed management planning to meet TMDL loading goals.

Financial support is often available for the implementation of BMPs to support water quality improvements. Among others, the Department's Soil and Water Program provides financial support for the development of such implementation plans. In order to be eligible for Section 319 subgrants, a complete watershed management plan, that includes the Nine Elements listed in Appendix A of this document, must be submitted to the Department's Section 319 program prior to deadlines established for annual or biannual requests for grant proposals. For more information on Section 319 program requirements, please contact the Department's 319 Nonpoint Source Implementation Program at 573-751-4932 or 800-361-4827. Local communities and citizens looking to develop organized watershed groups to improve water quality are also encouraged to contact the University of Missouri Extension at 573-882-0085. Information regarding the University Extension's water quality program is available online at fsb.missouri.edu/extension/waterquality/.

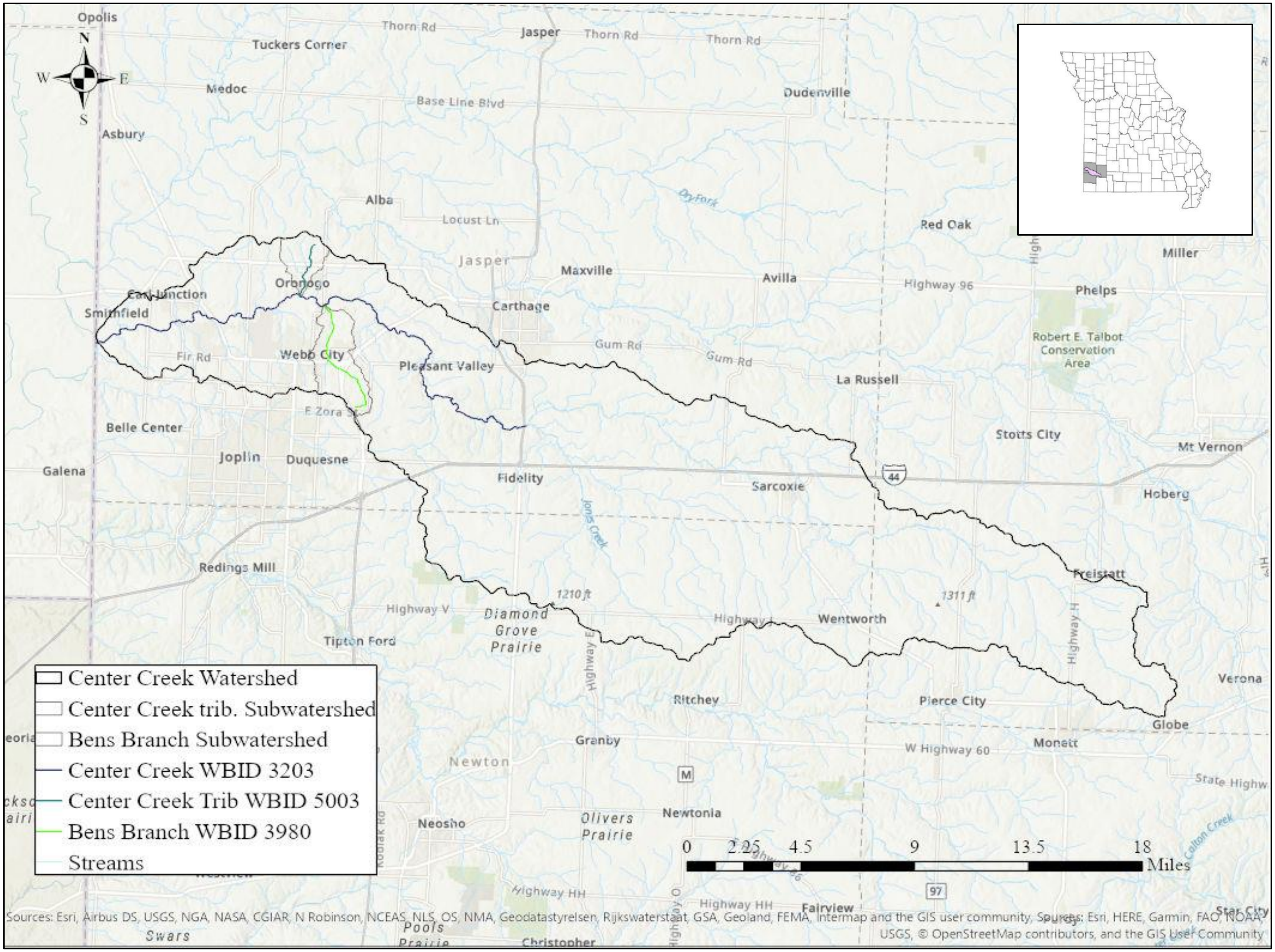

Figure 1. Center Creek Watershed (10-digit HUC 1107020706).

This document is also intended to provide a starting point from which watershed groups, municipalities, and stakeholders may begin planning and implementing watershed management practices, as well as applying for grant funding. This document includes some information and estimates related to the required elements of a nonpoint source watershed based plan. However, all information in this document should be independently verified prior to including the information in any official grant application. In general, this document touches on the following elements:

- Identification of the causes, sources, groups, or critical areas of similar sources that need to be controlled to achieve load reductions;
- Descriptions of nonpoint source management measures;
- Preliminary estimate of the amounts of financial assistance needed;
- Measurable Milestones; and
- Public education component to encourage participation.

Because each watershed management plan is uniquely tailored to the capabilities of the watershed group and the feasibility of implementation in each watershed, this document does not include the following elements:

- Estimates of expected load reductions;
- Final estimate of the amounts of technical and financial assistance needed;
- Schedule of implementation;
- Progress and Success Criteria; and
- Monitoring Program.

Potential nonpoint source management measures are evaluated in Section 8.

2. Targeted Participants and Potential Roles in Implementation

The Department implements TMDL targets for point sources through the Missouri State Operating Permit program. For nonpoint sources, private landowners and citizen groups voluntarily implement water quality improvement projects and cost-share practices, which may be funded in part by grants or subgrants from the Department's Section 319 Nonpoint Source Implementation Program and the Soil and Water Conservation Program. Local governments, citizen groups, and individuals who have an interest in improving water quality in their communities may implement additional water quality improvement actions. Successfully meeting the goals of a TMDL often requires participation and cooperation from various parties within a watershed. Participant roles range from technical support to actual on-the-ground implementation of BMPs. Groups and agencies that may potentially be involved in the TMDL implementation process are identified below along with descriptions of their possible roles. This list is not exhaustive and not intended to compel participation from any organizations; nor is it meant to exclude those who are not listed, but may be interested in participating.

- <u>Department of Natural Resources</u>
    - Administers statutory authorities granted by Missouri clean water law
    - Ensures permits issued in the watershed are consistent with the assumptions and requirements of TMDL wasteload allocations (the allowable point source load)
    - Provides compliance assistance to regulated entities
    - Provides technical support to locally-led watershed groups

  - Serves as a potential source of financial assistance for watershed plan development and BMP implementation through Sections 319(h) and 604(b) grants, or through Soil and Water Program cost-share practices, and federal technical assistances grants.
  - Serves as a potential source of financial assistance for infrastructure improvements through low-interest State Revolving Fund loans
  - Assesses attainment of water quality standards on a biennial basis for federal Clean Water Act Sections 303(d) and 305(b) reporting
  - Provides education and training to volunteers through the Missouri Stream Team Program[2]
  - Provides technical assistance for market-based approaches to compliance such as water quality trading
- <u>U. S. Environmental Protection Agency</u>
- <u>Tri-State Mining District Superfund Trustees; U.S. Fish and Wildlife Service, on behalf of the U.S. Department of Interior and the Missouri Department of Natural Resources on behalf of the people of Missouri.</u>
- <u>County Soil and Water Conservation Districts</u>
  - Provide financial incentives to agricultural producers to implement conservation practices that help prevent soil erosion and protect water quality
  - Provide technical assistance with design, implementation, and maintenance of conservation practices
- <u>University of Missouri Extension</u>
  - Provides technical assistance for addressing nonpoint source and watershed management issues
  - Assists with organizing locally led watershed groups
- <u>Missouri Department of Conservation</u>
  - Provides technical assistance with stream and watershed management issues
  - Promotes maintenance and reestablishment of stable streambanks and functional riparian corridors
- <u>Permitted entities within the Center Creek watershed</u>
  - Operate in accordance with stated permit limits, conditions and schedules
  - May participate in water quality trading implementation
- <u>Center Creek watershed Municipal Separate Storm Sewer System (MS4)</u>
  - Operate in accordance with stated permit conditions and schedules
  - May participate in water quality trading implementation
- <u>Locally led watershed groups</u>
  - Develop and implement Section 319-funded nine key element watershed-based plans.[3] (See Appendix A)
  - Identify critical areas at a local level

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[2] The Missouri Stream Team Program is a partnership between the Department of Natural Resources, the Department of Conservation, the Conservation Federation of Missouri, and the citizens of Missouri. The Stream Team Program provides an opportunity for all citizens to get involved in river conservation. Additional information regarding the Stream Team program is available online at mostreamteam.org.

[3] Guidance for developing a successful watershed-based plan that incorporates the U.S. Environmental Protection Agency's nine minimum elements is available online at www.epa.gov/nps/handbook-developing-watershed-plans-restore-and-protect-our-waters. These nine elements are required for plans funded with incremental Clean Water Act section 319 funds and are recommended for inclusion in all other watershed plans.

  - Implement BMPs to reduce nonpoint source pollutant loading
  - Provide public education and outreach
- Stream Team volunteers
  - Collect screening level water quality data (i.e., biological monitoring) through the Volunteer Water Quality Monitoring program
  - Provide stewardship, advocacy, and education
- Citizens living and working within the watershed
  - Voluntarily implement structural and nonstructural BMPs on private lands, residences, and businesses by controlling erosion and limiting runoff

3. Why was a TMDL Developed for the Center Creek Watershed?

Section 303(d) of the federal Clean Water Act and Title 40 of the Code of Federal Regulations Part 130 require states to develop TMDLs for water bodies not meeting applicable water quality standards. Missouri's Water Quality Standards consist of three major components: designated uses, water quality criteria, and an antidegradation policy. Descriptions of each of these components can be found in the Center Creek watershed TMDL document. Center Creek, Center Creek tributary, and Bens Branch are not attaining designated aquatic life protections for warm water habitat due to violations of Missouri's numeric and general criteria as evidenced by low quality benthic macroinvertebrate communities and excessive metals concentrations in sediments and the stream water column. As listed on the 2020 303(d) List of Impaired Waters, Center Creek impairments are attributed to historic Tri-State mining activities, and Center Creek tributary and Bens Branch impairments are attributed to historic Oronogo-Duenweg mining activities.

4. Sources and Remediation

The Center Creek watershed is located in the historic lead and zinc Tri-State Mining District (TSMD). The TSMD covers approximately 2,500 square miles in southwest Missouri, northeast Oklahoma, and southeast Kansas. The Oronogo-Duenweg Mining Belt (ODMB) is within the TSMD and is located northeast of Joplin, Missouri (Figure 2). The Springfield Plateau ecoregion, where the Center Creek watershed is located, is underlain by Mississippian-age cherty limestone. The breakdown of limestone in the Mississippian layers that are capped by Cherokee shales resulted in the development of porous chert layers, which overtime were filled by hot metal bearing materials originating from within earth. These layers are rich in zinc and lead minerals (Zinc Sulfide and Lead Sulfide), resulting in prolific mining operations in the region for nearly a hundred years. Mining production in the area started in the 1850s and the last mine closed in 1970. More than fifty years after mining operations ceased, mine-waste piles, groundwater discharges from underground mines, and adits[4] are a continuous sources of trace metals (primarily lead, zinc and cadmium) into the environment. After mining operations ceased, water was no longer pumped out of the tunnels, and this resulted in flooding of former mining operations. Once flooded, tunnel waters, in contact with ore bearing walls or residual ore bearing materials, become contaminated with various metal sulfides. The Oronogo-Duenweg Mining Belt alone produced over 10 million tons of mining and smelter waste. The resulting waste is the source of metal contaminated fine particulates which enter ground and surface waters impacting human and aquatic life in the region.

[4] A horizontal passage leading into a mine for the purpose of access or drainage.

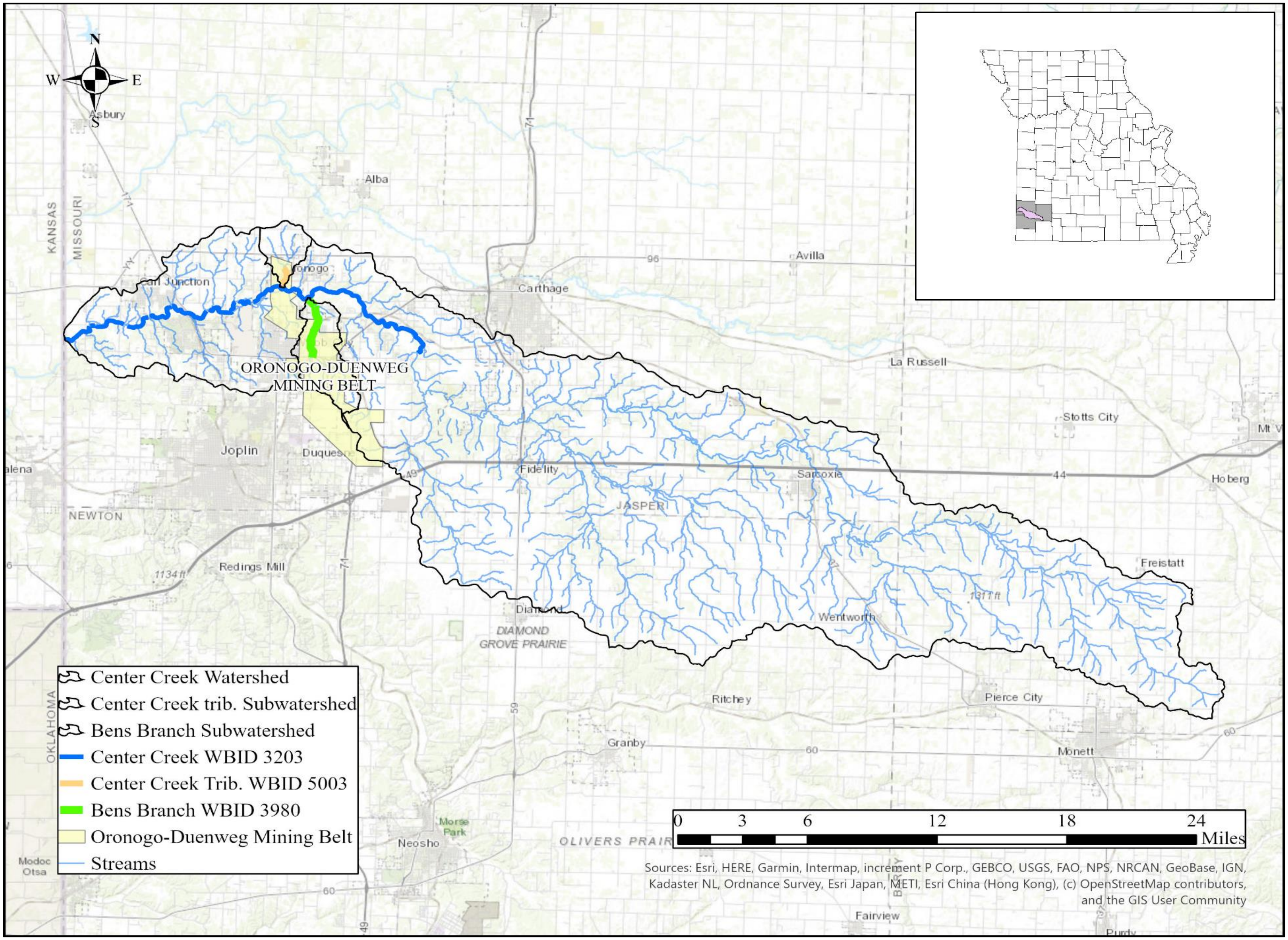

Figure 2. Locations of impaired stream segments and the Oronogo-Duenweg Mining Belt.

As described, abandoned mineshafts, adits, and mine waste materials serve as the primary source of metals contamination impacting the impaired stream segments in the Center Creek watershed. Management or remediation of these sources falls under the Comprehensive Environmental Response, Compensation, and Liability Act, or commonly known as Superfund. The National Priorities List assist the U.S. Environmental Protection Agency (EPA) with determining further investigation of these Superfund sites and guides ongoing monitoring, reclamation, and cleanup efforts.

In 1990 the Oronogo-Duenweg Mining Belt was listed on the Superfund National Priorities List along with 10 other designated areas in the TSMD. To oversee remedial efforts, EPA established five Operable Units (*OUs*) to address various contamination sources and cleanup actions. Table 1 summarizes *OU* actions and their current status as found in the Orongo-Duenweg Mining Belt Fourth Five Year Review Report (USEPA, 2017).

Table 2. Five Operable Units established for the Oronogo-Duenweg Mining Belt Superfund Site.

Operable Unit	Action	Status
OU1	Mining and Mill Waste Removal	Ongoing
OU2	Smelter Waste Residential Yards	Completed
OU3	Mine Waste Residential Yards	Completed
OU4	Shallow Groundwater	Completed
OU5	Perennial Streams (water and sediment)	Remedial Investigation/Feasibility Study Stage

Each *OU* contains remedial components such as the removal of mine and mill waste, contaminated soils and stream sediments, subsurface removal of excavated source materials, contouring and revegetation, shaft plugging and mine water diversion, establishment of public health education programs and site monitoring to access site cleanup progress among others. The following paragraphs provide further detail regarding *OU1* remedial actions, as this unit focuses on the remediation of lands which include the streams and portions of their watersheds addressed in the Center Creek watershed metals TMDL document. Potential runoff from these lands will be further addressed under the *OU5* Record of Decision and the subsequent remedial actions.

Actions taken under *OU 1* included the EPA signing an Engineering Evaluation/Cost Analysis in August 2002, which designated an open time framed mine waste removal action in the Oronogo-Duenweg Mining Belt. Under *OU 1* mine waste was excavated, used as fill, and capped during construction of the Route 249 Highway Project. Remediation required removing the top 12 inches of soil below waste piles, incorporation of waste with existing construction fill, storm-water controls, dust suppression, capping of waste sites exceeding 1,500 ppm lead, and revegetation of disturbed areas.

In September 2004, the EPA signed a Record of Decision to cleanup mining waste under *OU 1* across the site. Table 2 details Removal Action Objectives as part of the Record of Decision, under *OU 1*.

Table 3. Removal Action Objectives for *OU 1* for 2004 Record of Decision (USEPA, 2017).

Action	Objectives
Source Materials	Mitigate risk to terrestrial vermivores[5] from exposure to contaminants of concern (COC) resulting from mine, mill, and smelter waste within the ODMB, such that calculated toxicity quotients or hazard indexes are less then or equal to 1.0.
Sediments	Mitigate risks to aquatic biota in class P streams and their tributaries exceeding federal Aquatic Life Criteria[6] for COCs by controlling transport of mine, mill, and smelter waste from source areas to waters of the state.
Surface Water	Mitigate exposure of aquatic biota to COCs released and transported from mine and mill wastes where applicable or relevant and appropriate requirements for surface water are exceeded in Class P streams and tributaries.
Surface Water	Mitigate exposure of aquatic biota to COCs released and transported from ODMB mine-related pits and ponds where surface water applicable or relevant and appropriate requirements are exceeded in Class P streams and in tributaries.
Groundwater	Mitigate exposure of aquatic biota to COCs in releases of groundwater from flowing mine shafts at the ODMB where surface water applicable or relevant and appropriate requirements are exceeded in Class P streams and in tributaries

Initial remedial actions described in Table 2 commenced in November 2007. To date, 4,200 acres out of the approximately 11,000 acres of *OU1* have been remediated, this included the removal, disposal, and capping of 16 million cubic yard of mine waste and contaminated soils. In addition, approximately 13 miles of intermittent stream has been remediated. It is expected to take an additional three to five years to complete planned remediation actions. As previously discussed, *OU5* is in the Remedial Investigation/Feasibility Stage. Once the *OU5* Record of Decision is completed further protective actions will be put in place to remediate and protect impacted surface waters.
In May of 2012, the Missouri Trustee Council (Trustees), made up of the State of Missouri, the Missouri Department of Natural Resources, and the U.S. Department of the Interior represented by the U.S. Fish and Wildlife Service, finalized the Springfield Plateau Regional Restoration Plan and Environmental Assessment (SPRRP). The SPRRP is a comprehensive plan describing how the Trustees shall allocate recovered funds to restore natural resources damaged by the release of hazardous waste within the Springfield Plateau (USFWS, 2018). The Trustees have developed the Draft Restoration Plan and Environmental Assessment to supplement the SPRRP. The Cardinal Valley Natural Habitat Restoration project objectives include the restoration of portions remediated mine waste lands to native prairie, restored wetlands, and the introduction of riparian buffers. The Trustees established five alternatives to address restoration actions throughout the Orongo-Duenweg Mining Belt, Alternative 4 was chosen and consists of organic soil amendment (manure, biosolids, and compost) actions and habitat restoration. Organic soil amendments have shown to assist with remediation effort by changing or binding contaminants in soils. Alternative 4 actions include up to a 160 dry tons per acre over three-year soil amendment application rate, site mowing, herbicide applications, seasonal burning, seeding and planting, and the addition of conservation land easements.

[5] Feeds on worms
[6] National Recommended Aquatic Life Criteria:
https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table

Figure 3. On the left, EPA remediated lands near Webb City purchased for future restoration. On the right, remnant historic prairie located nearby in Newton County, representative of desired future restoration (Image citation, 2018 USFWS).

5. Water and Sediment Impairments

Sediment and water samples from Center Creek, Center Creek tributary, and Bens Branch have been collected by several agencies over the last several decades to determine attainment of water quality standards. The Department assesses a stream (water column) to be impaired for metals if the numeric water quality criteria are exceeded in any one of the last three years for which data is available. For toxic chemicals occurring in sediments, a geometric mean is calculated from an adequate number of samples and compared to a corresponding Probable Effect Concentration (PEC) (MacDonald et al., 2000). The PEC value represents a pollutant level at which harmful effects on an aquatic community will likely be observed. The Department uses 150 percent of the PEC values to account for variability in the assessment of sediment toxicity. To assess the synergetic impacts of multiple metals in the water column the Department applies the PEC Quotient (PECQ). The PECQ represents a ratio value of the geometric mean of metal concentrations over the associated PEC metal's value. PECQ values over a ratio of 0.5 are consider conditions which are harmful to warm water aquatic species, waters are assessed as impaired if the PECQ value exceeds 0.75 (MacDonald et al., 2000). Assessment data are summarized in Section 4 of the Center Creek watershed metals TMDL.

6. Existing Loads and Needed Reductions

Missouri's Water Quality Standards include specific numeric metals and general criteria for waters designated for the protection warm water of aquatic life. Metals concentrations which are protective of warm water aquatic life serve as the numeric targets for TMDL development for the impaired stream segments in the Center Creek watershed. Cadmium, lead, and zinc are the three metals causing impairments to warm water aquatic life in Center Creek, Center Creek Tributary, and Bens Branch. As discussed in Section 4, the primary source of metals loading to streams are the historic mining activities in the region. Existing water quality loads are represented by instream water quality data,

and reductions are determined by the load duration curve approach. Load duration curves identify the allowable daily pollutant load as a function of the flow occurring on that day within the stream. The following load duration curves depict instream sample data as points in reference to the water quality criteria, which is represented by the red curve across various flow scenarios (high, low, mid-range, etc.). Data points located above the criteria curve represent exceedances in water quality criteria, with data below the line meeting water quality criteria for a given parameter. Identifying flow conditions where exceedances most commonly occur for a particular water body can help identify BMPs address load reductions. Figure 5 provides an example of a load duration curve used to develop load allocations in the Center Creek watershed. The remaining load duration curves are provided in Appendix B.

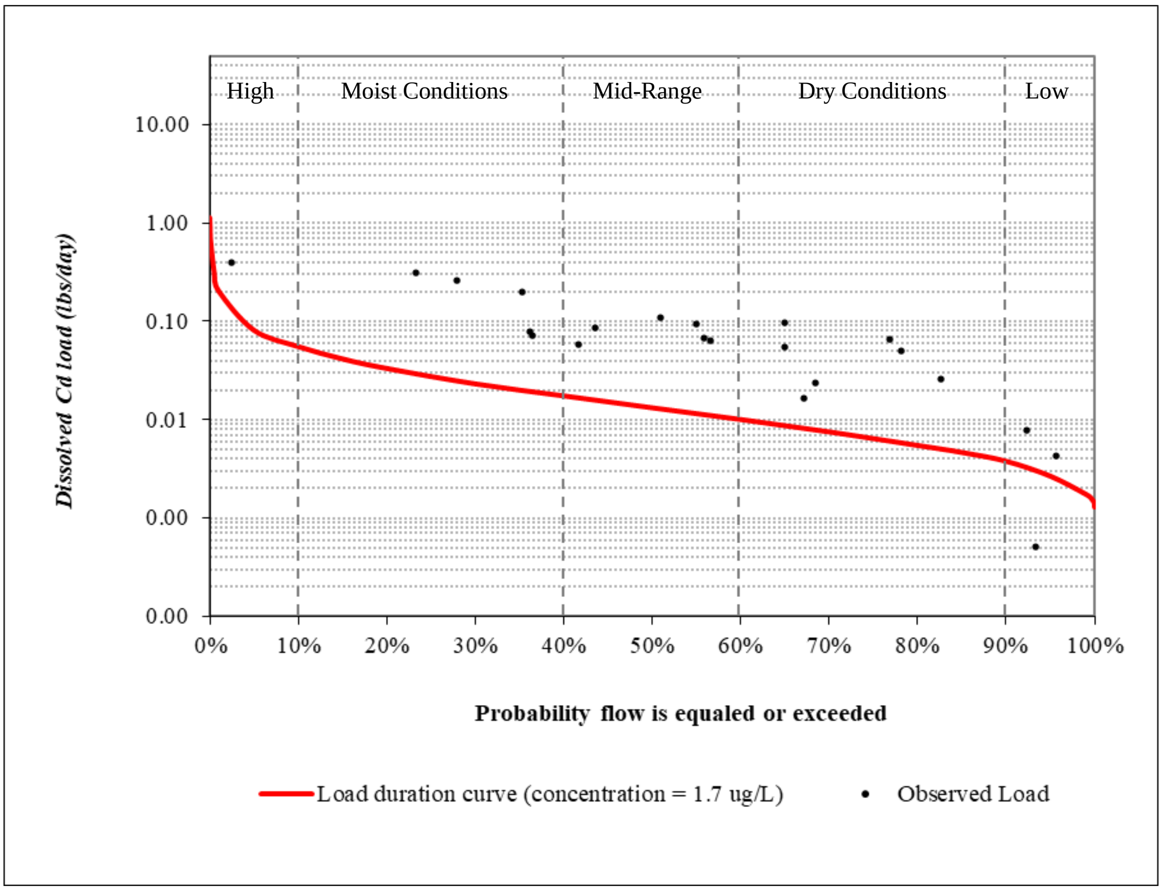

Figure 4. Center Creek Tributary (WBID 5003) dissolved cadmium load duration curve

In the figure above the red line represents dissolved cadmium water quality criteria across varying flow regimes, the points represent observed loads estimated from monitoring data collected from the impaired stream. In this example reductions are necessary across relatively all flow conditions. Cadmium reductions may require several BMPs which are effective across various flow conditions, while lead exceedances for Center Creek tributary occur at relatively dry conditions and may be addressed with a specific set of BMPs. TMDL allocations are made for point and nonpoint sources found within the impaired stream's watershed. The Table 5 is an example of TMDL allocations for Center Creek Tributary. The remaining TMDL allocations are provided in Appendix B.

Table 4. Dissolved cadmium TMDL and allocation values for Center Creek tributary (WBID 5003) at selected flows.

Percent of time flow equaled or exceeded	Flow ft^3/s (m^3/s)	TMDL (pounds/day)	∑WLA (pounds/day)	∑LA (pounds/day)	∑MS4 WLA (pounds/day)	MOS (pounds/day)
95	0.3 (0.008)	0.003	0.0002	0.002	0.0002	0.0003
75	0.7 (0.020)	0.006	0.0006	0.005	0.0006	0.0006
50	1.4 (0.040)	0.013	0.0013	0.011	0.0013	0.0013
25	3.0 (0.085)	0.027	0.0027	0.022	0.0027	0.0027
5	8.8 (0.250)	0.081	0.0082	0.064	0.0082	0.0081

As with the load duration curve figure, the example table breaks down TMDL allocations across a series of selected flow regimes. Allocations are expressed in pounds per day, with the wasteload allocation (WLA) designated to permitted point sources. The load allocation (LA) is designated to non-point sources. A margin of safety (MOS) allocation is included to account for uncertainty and assure water quality standards are attained after point and nonpoint source allocations are met. To meet wasteload allocation targets permitted entities will have permit limits adjusted to meet desired targets. Reduction necessary to meet targets are often addressed with facility technological improvements, adjustments to wastewater treatment processes, and on-site BMPs. Nonpoint reductions are often addressed using BMPs which best address the contaminant ant of concern.

While BMPs are often associated with and implemented for sediment erosion and nutrient loss controls from agricultural landscapes, BMPs which offer sediment erosion control can also assist with metals contamination loading. Keeping contaminated waste and soils in place, while reducing exposure to ground and surface waters, can improve instream aquatic life conditions. The following section reviews several examples of sediment erosional control BMPs as well as metals specific practices which can assist with nonpoint metals loading from contaminated lands and other metals sources.

7. Potential Point Source Management Measures

Point source discharges in the Center Creek watershed can contribute metals loading to the impaired stream segments. These industrial and domestic facilities which discharge metals in their effluent have permit specific metals limits to protect water quality. Although, due to abundance of contaminated lands, movement of mine tilings and use of as mine waste backfill in the region metals contamination can prevalent in domestic sewage and storm water collection systems through inflow and infiltration (I&I). Facilities receiving metals contaminated influent must treat these waters to meet permit limits and conditions. Conventional wastewater treatment processes such as chemical precipitation, adsorption, electrochemical deposition, and flotation are methods applied for metals removal from domestic and industrial wastewater. Additional treatment methods include membrane filtration and designed tertiary wetland systems. These treatment methods can be challenging and expensive, ultimately facilities should maintain a comprehensive collection management plan to prevent and address inflow and infiltration concerns throughout their collection systems in the region to minimize metals contamination.

8. Potential Nonpoint Source Management Measures

Strategies which reduce loading from abandoned mines and lands impacted by mining activities within the Center Creek watershed should be the focus of nonpoint source management. Impacted

lands, especially those within the 100-foot buffer of the impaired streams and their tributaries, are "critical areas" where nonpoint source management measures will be most effective. Also included is the footprint of the Oronogo-Duenweg Mining Belt Superfund site. Remediation efforts are ongoing in this area, yet the addition of new or modifications to existing BMPs may further reduce metals loading to surface waters. In addition, existing remediated grounds beyond the Superfund footprint are targets for stabilization and vegetative cover. The following sections provide examples of BMPs to assist with metals loading reductions to the impaired streams, Figures 6-8 depict critical areas within each water body catchment.

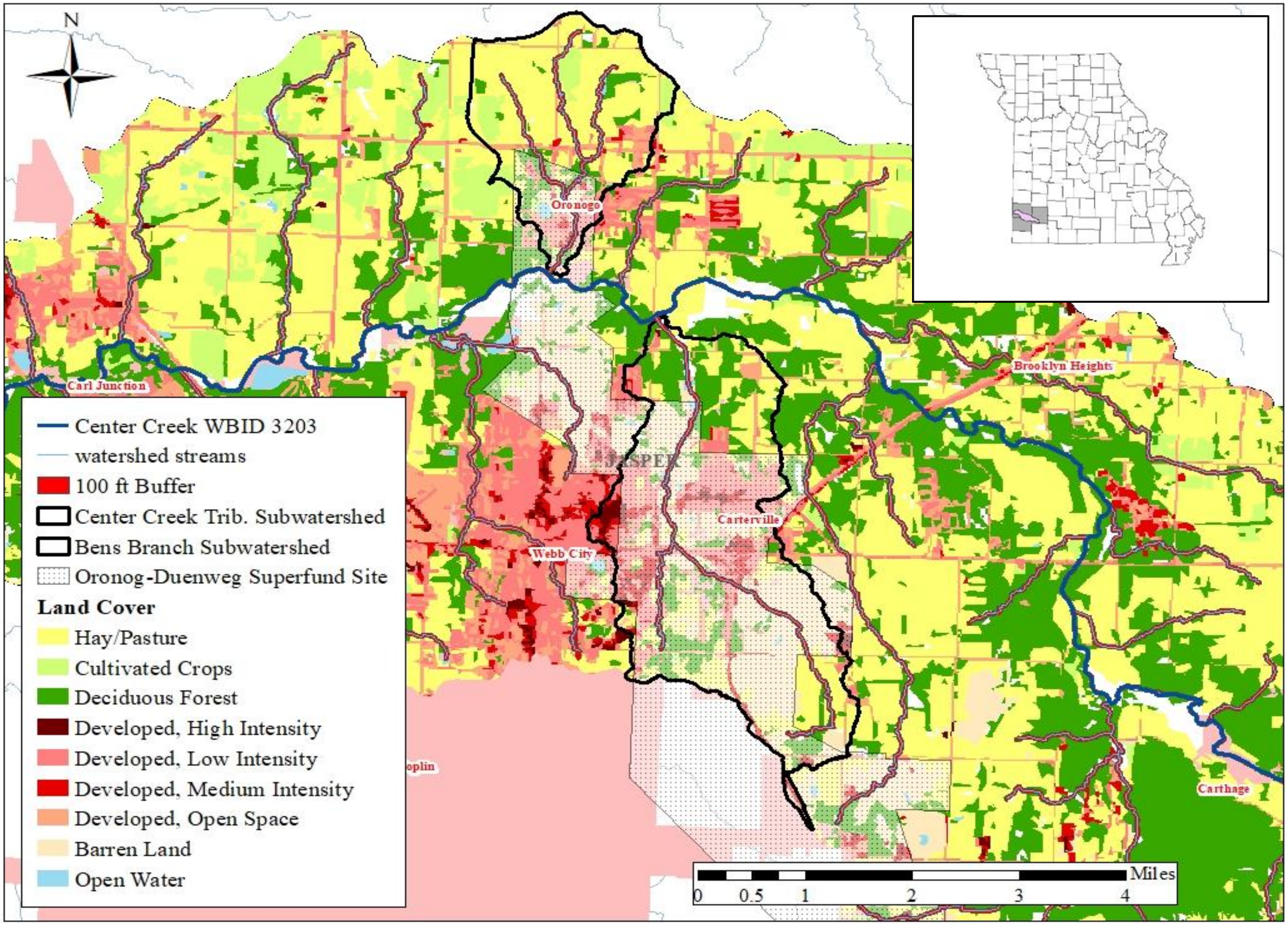

Figure 5. Critical 100 foot stream channel buffer areas in the Center Creek (WBID 3203) watershed.

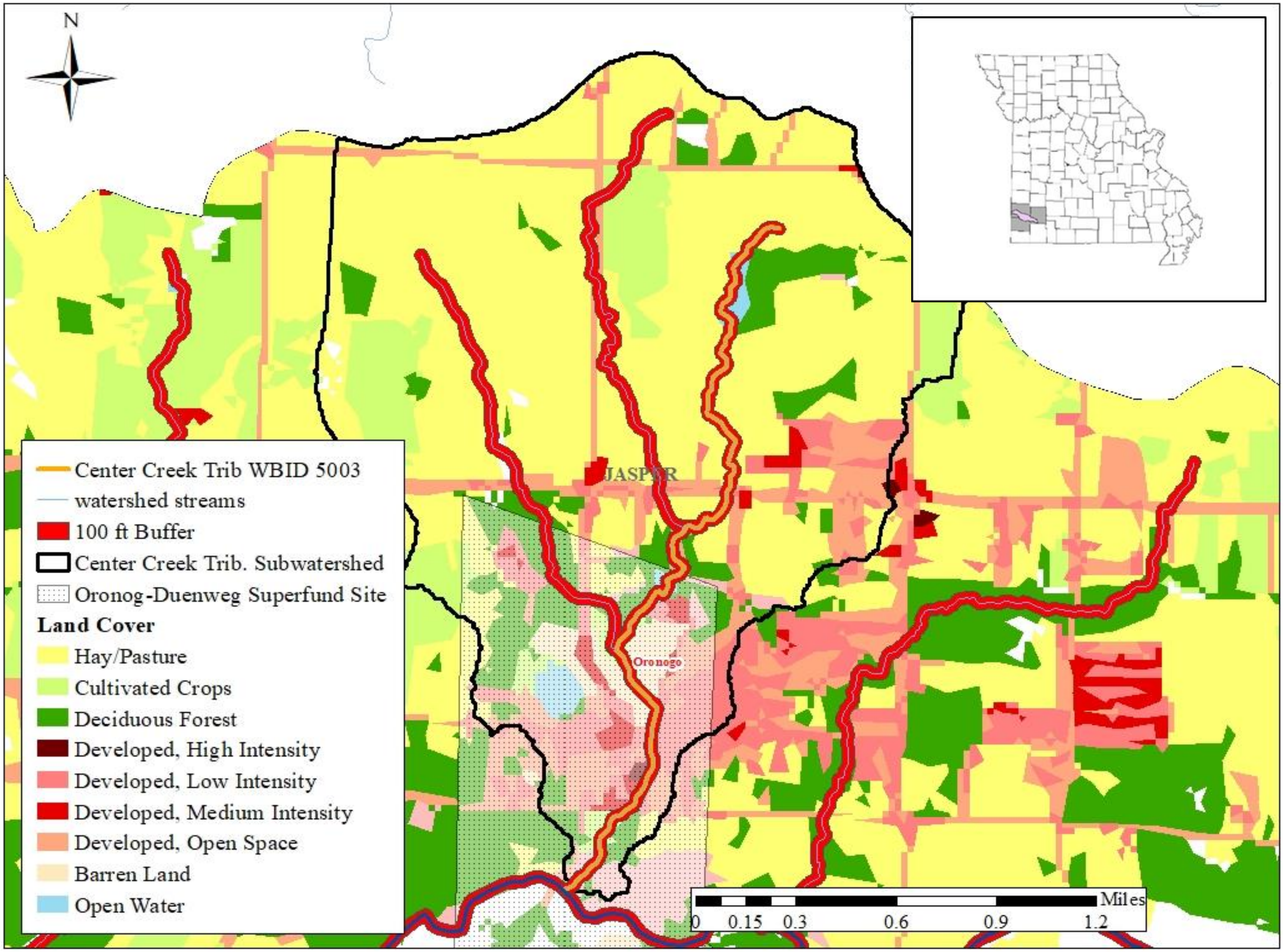

Figure 6. Critical 100 foot stream channel buffer areas in the Center Creek Tributary (WBID 5003) catchment.

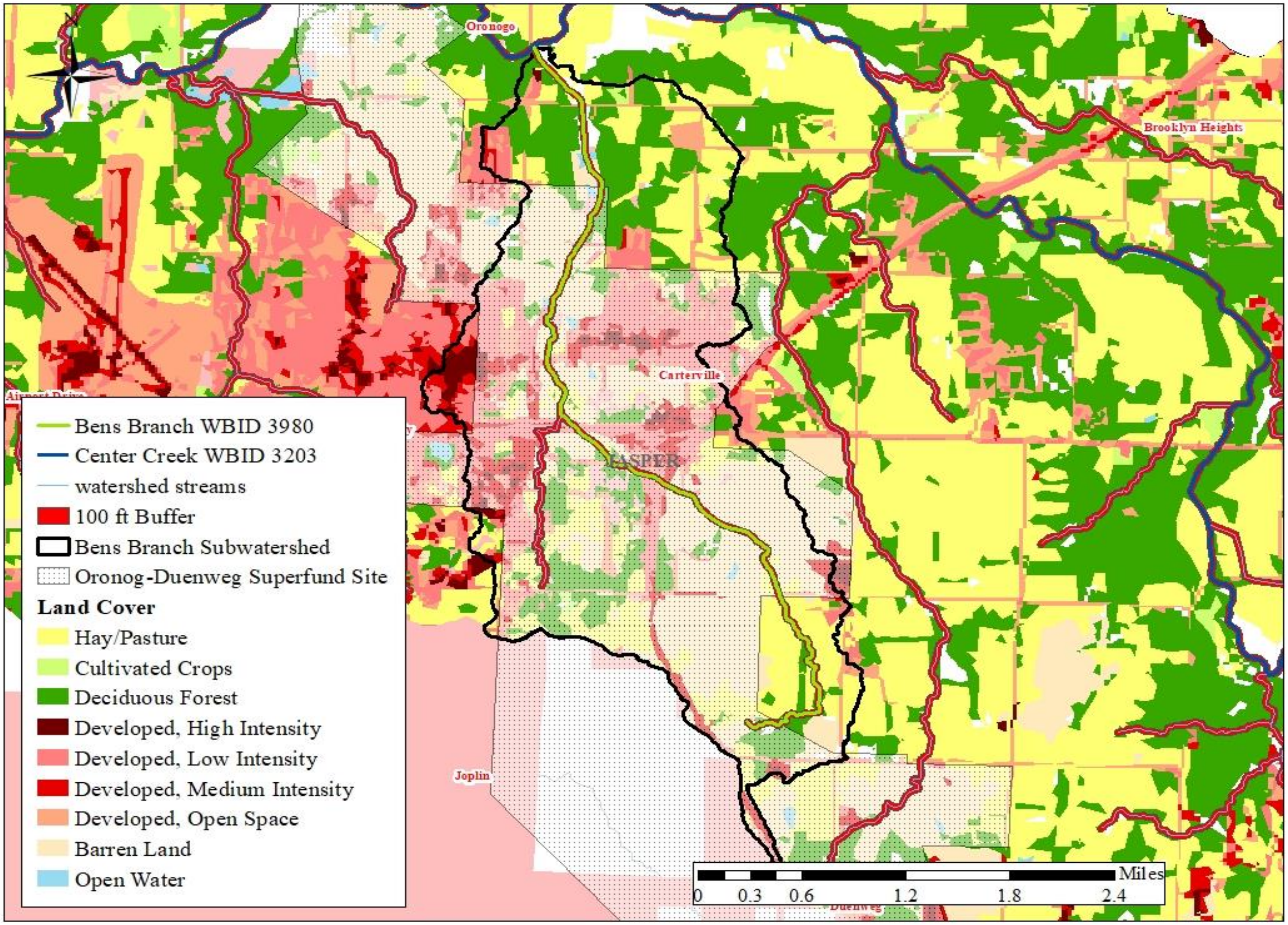

Figure 7. Critical 100 foot stream channel buffer areas in the Bens Branch (WBID 3980) catchment.

8.1 Riparian Buffers

Riparian corridor conditions have a strong influence on instream water quality. Wooded riparian buffers are a vital functional component of stream ecosystems and are instrumental in erosion reduction, as well as the detention, removal, and assimilation of pollutants in runoff. Therefore, a stream with good riparian cover is able to mitigate the impacts of high pollutant loads better than a stream with poor or no riparian cover. Shade provided by riparian corridors is also important because it helps to keep water cooler and reduce temperature variation especially during the critical low flows of July and August.

Pasture land, cultivated crops and barren lands (abandoned mine lands) directly adjacent to the impaired waters and their tributaries are lands ideal for riparian establishment. Creating riparian corridors within the 100-foot buffer of the streams will reduce erosion and transport of contaminated soils from the adjacent lands. The total area of stream buffer and stream lengths that could benefit from the creation of riparian buffers are summarized in Table 6. These areas and lengths include all stream channel within the Center Creek watershed and within the Oronogo-Duenweg Mining Belt Superfund footprint.

Table 5. Summary of potential riparian establishment within 100-foot buffer of the Center Creek watershed and ODMD footprint.

Catchment	Land Use	Acres	Linear feet	Linear Miles
Center Creek Watershed	Hay/Pasture	3,813	2,814,036	533
	Cultivated Crops	201	233,444	44
	Barren Lands	130	83,196	16
ODMB Footprint	Hay/Pasture	33	27,115	5
	Cultivated Crops	6	5,400	1
	Barren Lands	111	66,123	13

8.2 Streambank Stabilization

In addition to the creation of riparian buffers, areas adjacent to the impaired waters and their tributaries are targeting unstable or eroding streambanks for stabilization measures. Materials from contaminated soils can sluff and erode into stream channels. Targeting streambank erosional areas known to have mine fill or high metals concentration (Superfund site) soils should have highest prioritization for stabilization. Such measures may include the installation of live stakes, coconut fiber rolls and mesh, coir rolls, bank terracing, large woody debris, and large boulders to support streambanks and reduce erosion. Integrating shrub and tree planting with other bank stabilization

measures results in long-term stabilization as the vegetative roots expand and provide further soil stability. Many resources are available to guide streambank stabilization design for specific conditions. Two helpful initial references are the *Army Corps of Engineers Streambank and Shoreline Protection Manual* (https://www.lrc.usace.army.mil/Portals/36/docs/regulatory/pdf/StrmManual.pdf) and Missouri Department of Conservation's habitat care website (https://mdc.mo.gov/property/improve-my-property/habitat-management/pond-stream-care).

8.3 Phytoremediation

8.3.1 Phytoextraction

Phytoextraction or phytoaccumulation is the natural process by which plants uptake contaminants purifying soils. Natural mechanisms allow plants to bioaccumulate metals based on nutrient requirements. Particular plants termed "hyperaccumulators" which have a propensity to uptake or absorb non-essential elements (heavy metals) at a greater rate than other typical cover vegetation species can be used to target metals contamination. Hyperaccumulators can establish and grow in locations with high metals concentrations, and have the ability to assimilate metals beyond typical maximum threshold limits (Shrivastava et al., 2019). Willows (*Salix* spp.), sunflowers (*Helianthus* spp.), rapeseed (*Brassica napus*), Indian mustard (*Brassica juncea*), and common buckwheat (*Fagopyrum esculentum*) are excellent hyperaccumulators of heavy metals (Honda et al. 2007; Madejon et al. 2003; Meers et al. 2005; Meers et al. 2006). Species which support metals extraction and the accumulation in their biomass can be harvested, then processed to dispose of the metals appropriately. It should be noted that phytoextraction is a contaminant transfer processes, and the disposal or storage of the contaminant remains to be addressed.

8.3.2 Rhizofiltration

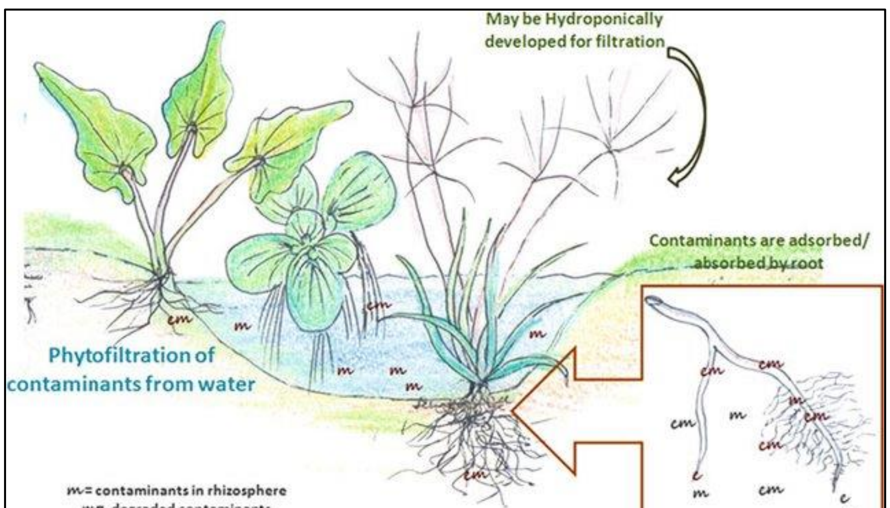

Image citation: Datta et al., 2013

This remediation process is the treatment of ground, surface, or waste waters via the root zone or plant root mat system. This practice is often used in an agricultural setting using cover crops to address nutrient contaminants, but can be applied to various other environmental contaminants. Similar to phytoextraction, rhizofiltration accumulates contaminants in the selected plants biomass. The primary difference between phytoextraction and rhizofiltration is that rhizofiltration is typically applied in aquatic environments, whereas phytoextraction is applied to terrestrial settings. Under controlled conditions a variety of plant species have shown to be effective at accumulating and assisting with precipitation of metals in aqueous environments. For example, the roots of Indian mustard have the ability to assimilate or precipitate an assortment of metals, effectively removing them from the aqueous environment (Dushenkov et al., 1995). Constructed wetlands may be an effective BMP to address metals in

watersheds (Liu et al., 2007). As mentioned previously, metals accumulated within plant biomass will need to be disposed of or stored appropriately when applying this practice.

8.3.3 Phytovolatilization

Phytovolatilization, also a variant of phytoextraction, is the process by which harmful contaminants are transformed and volatilized into a less harmful form. This occurs when plants uptake metals and they are volatilized into the atmosphere via evapotranspiration (Datta et al., 2013). Although the process is timely, it does not require the removal of vegetation to achieve remediation effects. Generally, phytovolatilization remediation targets metals which are more readily biomethylated, such as arsenic, selenium, and mercury.

8.3.4 Phytostabilization

Phytostabilization is the use of metal tolerant plant species to prevent erosion, transport, and leaching of contaminants into the surrounding environment, essentially holding the contaminants in the root zone. Revegetation reduces metals contaminated soil particle dispersion via erosional processes, while stabilizing and reducing bioavailability of metals via rhizosphere absorption and precipitation processes. Revegetation increases soil organic carbon (SOC) which is critical for improving soil health. Generally, soil health can be considered the physiochemical and biological condition of a soil, revegetation also increases biological activity, improves nutrient availability, and increases soil cation exchange capacity. Plants with extensive root systems and high biomass production are ideal, with relatively low root to shoot translocation of metals to prevent transfer into the food web via wildlife foraging (Rizzi et al., 2004). The addition of soil amendments, such as manure, compost, biosolids and biochar is an also important component of the phytostabilization process.

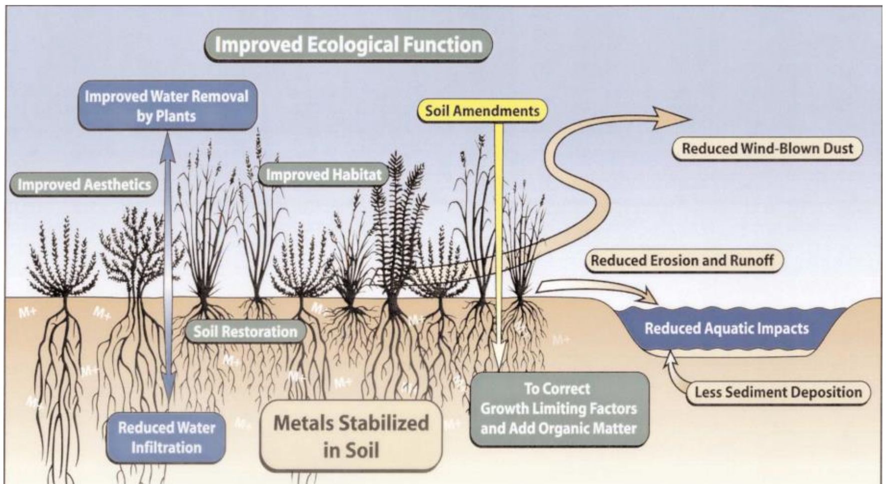

Image Citation: Pierzynski et al., 2004

9. Preliminary Estimate of Financial Assistance Needed

Table 7 provides initial cost estimates derived from the Missouri's June 2019 Standardized State Average Cost List, these costs were developed in coordination with National Resource Conservation Service, Farm Service Agency and the Department's Soil and Water Conservation Program. Additional maintenance cost, such as mowing and weed management, are necessary with these best management practices and should be considered in cost estimates. These are general estimates, and should be independently verified prior to inclusion in grant proposals.

Table 6. Estimated Cost Share by Practice.

Practice	Estimated Cost	Critical Area	Total Estimated Cost	Cost/Benefit Efficiency Rank
Riparian Buffer/Hardwood Planting	$250.00/ac.	694 acres	$173,000	Low
Streambank Stabilization[A]	$21.00/ft	6,000 ft[B]	$120,000	High

[A] Cost include labor for tree investment installation and willow planting.
[B] Approximately 60,000 feet of stream channel exist in the superfund footprint, 10% targeted for stabilization.

10. Potential Funding Sources

TMDLs are written to meet applicable water quality standards per federal regulations at 40 CFR 130.7(c)(1). As a result, they are developed without considerations of cost or available treatment technologies. However, BMP installations result in real-world costs that need to be considered before determining what technologies or actions to employ in order to meet the calculated water quality targets. In many cases, TMDL implementation is partially a continuation of already permitted activities and costs are incurred as part of the normal operation and maintenance of those permitted systems. Other point source costs may arise as a result of needed facility upgrades in order to meet specified permit limits or conditions. For nonpoint sources, costs associated with installing and maintaining BMPs depend upon the type, number, and complexity of the practice. Fortunately, a single BMP may address several pollutants or degradation pathways, thereby compensating for the overall costs by providing additional water quality benefits. Estimates of BMP costs are available online from the International Stormwater BMP Database at bmpdatabase.org.

A variety of grants and loan programs are available to assist watershed stakeholders to offset costs associated with facility upgrades or BMP implementation. The most commonly used sources of funding are low-interest loans through the State Revolving Fund, Section 319 subgrants, and cost-share practices through the state's Soil and Water Conservation Program.

Low-interest loans from the Clean Water State Revolving Fund are available to wastewater treatment facilities through the Department's Water Protection Program Financial Assistance Center. The State Revolving Fund provides subsidized loans to municipalities, counties, public sewer districts, and political subdivisions for wastewater infrastructure projects. Loans may be paired with grant funds for qualifying communities. Information on the Department's grant policy is available online at dnr.mo.gov/water/business-industry-other-entities/financial-opportunities. Eligible projects include new construction or improvement of existing facilities. More information regarding the State Revolving Fund Program is available online at dnr.mo.gov/water/business-industry-other-entities/financial-opportunities/financial-assistance-center.

By amendment to the federal Clean Water Act in 1987, the Section 319 grant program was established to provide funding for efforts to reduce nonpoint source pollution. EPA provides 319 funding to the state, which in turn allocates a portion of the funding as subgrants to public and non-profit organizations to address nonpoint source concerns. Section 319-funded subgrants may be used to demonstrate innovative BMPs, support education and outreach programs, restore impaired waters, or protect waters from becoming impaired. More information regarding the Section 319 Nonpoint Source Implementation Program is available online at dnr.mo.gov/water/what-were-doing/nonpoint-source-pollution-section-319.

The Soil and Water Conservation Program provides financial incentives to landowners to implement practices that help prevent soil erosion and protect water quality. The program offers cost-share practices through its county conservation districts. Landowners may receive up to 75 percent reimbursement of the estimated cost of a practice through the program. The primary funding for cost-share practices from the Soil and Water Conservation Program comes from the one-tenth-of-one percent Parks, Soils, and Water Sales Tax. More information regarding the Soil and Water Conservation Program and cost-share practices is available online at dnr.mo.gov/land-geology/soil-water-conservation.

In addition to state sources of funding, federal assistance, public bonds, and private financing may also be available for TMDL implementation. For example, the U.S. Department of Agriculture through its Natural Resources Conservation Service provides various incentive and financial assistance programs for implementing BMPs that reduce pollutant loading from agricultural areas. Additionally, the EPA maintains the Catalog of Federal Funding, which is a searchable database for other financial assistance sources. Table 8 provides links to these as well as other federal funding sources.

Table 7. Online resources for potential funding sources

Name and URL	**Description**
U.S. Department of Agriculture Natural Resources Conservation Service https://www.nrcs.usda.gov/wps/portal/nrcs/site/mo/home/	Financial assistance and incentives to implement voluntary BMPs º Environmental Quality Incentives Program (EQIP) º Regional Conservation Partnership Program (RCPP) º Conservation Stewardship Program (CSP) º Agricultural Conservation Easement Program (ACEP)
Wichita State University, Environmental Finance Center (EFC) https://www.wichita.edu/academics/fairmount_college_of_liberal_arts_and_sciences/hugowall/efc/news/meramec-funding-sources-landing-page.php	Searchable database of funding opportunities
Catalog of Federal Funding https://www.epa.gov/waterdata/catalog-federal-funding	Searchable database for financial assistance sources
Nonpoint Source – Related Funding Opportunities http://water.epa.gov/polwaste/nps/funding.cfm	List of federal websites with information regarding funding opportunities
Environmental Education Grants http://www2.epa.gov/education/environmental-education-ee-grants	Financial support for environmental education projects
Environmental Justice Grants https://www.epa.gov/environmentaljustice/environmental-justice-grants-and-resources	Grant resources for Environmental Justice communities
Water Infrastructure and Resiliency Finance Center https://www.epa.gov/waterfinancecenter	Provides financing information for drinking water, wastewater and stormwater decisions

Grants.gov http://www.grants.gov	A common website for federal agencies to post funding opportunities

11. Measurable Milestones

Watershed management plans must be renewed every five years to stay eligible for Section 319 subgrants. Thus, specific goals and objectives should be developed on 5-year timeframes. The following milestones are intended to support maximum BMP implementation on a 20-year timeframe, with on-going funding disbursements based on the interim 5-year timeframes.

5-Year Milestones

- Conduct outreach and gain public participation for implementing BMPs and achieving nonpoint source load reductions in the long-term.
- Evaluate where wetlands may be constructed to provide heavy metal attenuation.
- Fund and construct bank stabilization and associated riparian buffer projects that include hypoaccumulators along 10 percent of stream linear feet adjacent to hay, pasture, barren, and abandoned mine lands in the Center Creek watershed.

10-Year Milestones

- Continued outreach and public participation for implementing BMPs and achieving nonpoint source load reductions in the long-term.
- Fund and construct wetlands in strategic locations to reduce heavy metal transport.
- Complete construction of bank stabilization and associated riparian buffer projects that include hypoaccumulators along 25 percent of stream linear feet adjacent to hay, pasture, barren, and abandoned mine lands in the Center Creek watershed.

15-Year Milestones

- Continued outreach and public participation for implementing BMPs and achieving nonpoint source load reductions in the long-term.
- Complete construction of bank stabilization and associated riparian buffer projects that include hypoaccumulators along 50 percent of stream linear feet adjacent to hay, pasture, barren, and abandoned mine lands in the Center Creek watershed.

20-Year Milestones

- Continued outreach and public participation for implementing BMPs and achieving nonpoint source load reductions in the long-term.
- Complete construction of bank stabilization and associated riparian buffer projects that include hypoaccumulators along 85 percent of stream linear feet adjacent to hay, pasture, barren, and abandoned mine lands in the Center Creek watershed.

12. Public Outreach Program and Strategy

Education and outreach activities are designed to inform the public on BMPs and conditions that relate directly to improvement of water quality within the watershed. Many avenues for outreach are available to residents of the watershed. Organizations such as the EPA, Natural Resources

Conservation Service, Soil and Water Districts, Missouri Department of Conservation, University of Missouri Extension, municipalities in the greater Joplin area and the Jasper County Health Department provide much needed information to landowners regarding BMPs and give technical advice on practices or services that will benefit the land and water quality in the watershed.

The following activities are recommended for the development of support and participation to reduce nonpoint source loading to the Center Creek watershed.

1. Hold meetings and other outreach events to inform private landowners of the available technical support and financial incentives for implementing BMPs.
2. Attend livestock auctions and demonstrations in the local community, and hand-out literature explaining the available technical support and financial incentives for implementing BMPs to reduce erosion.
3. Develop small-scale demonstrations of BMPs.
4. Implement a public awareness campaign regarding water quality with public service announcements.
5. Host local watershed festivals.

13. Conclusion

The purpose of this TMDL implementation strategies document is to serve as a general guide to Department staff, soil and water conservation districts, local governments, permitted entities, watershed managers, and citizen groups for reducing existing pollutant loads to restore Center Creek, Center Creek tributary, and Bens Branch to conditions that attain water quality standards. The ultimate goal is to meet Missouri Water Quality Standards through the protection of aquatic life in warm water habitats. Implementation should follow an adaptive approach that makes progress toward achieving water quality goals while using new data and information to reduce uncertainty and adjust implementation activities. Implementation efforts are expected to occur over a number of years, but within the schedules established in state operating permits and Section 319 watershed-based plans. Success in achieving water quality standards will be determined by the Department through biennial assessments of water quality compliance as required by Sections 305(b) and 303(d) of the federal Clean Water Act.

The Department has an administrative record on file for the Center Creek watershed metals TMDL for Center Creek, Center Creek tributary, and Bens Branch. This information is available upon request to the Department at https://missouridnr.mycusthelp.com/WEBAPP/_rs/(S(yyfbnlunlybpcx0h30xkhm4q))/supporthome.aspx. Any request for information about this TMDL will be processed in accordance with Missouri's Sunshine Law (Chapter 610, RSMO) and the Department's administrative policies and procedures governing Sunshine Law requests. For more information about open record/Sunshine requests, please consult the Department's website at dnr.mo.gov/open-records-sunshine-law-requests.

This implementation strategies document is scheduled for a 45-day public notice and comment period in conjunction with the comment period for the Center Creek watershed metals TMDL document. Any comments received, as well as the Department's responses to those comments, will be maintained on file with the Department and posted online at. The Department maintains an email distribution list for notifying subscribers of significant TMDL updates or activities. Those interested in subscribing to these

TMDL updates can submit their email address using the online form at public.govdelivery.com/accounts/MODNR/subscriber/new?topic_id=MODNR_177.

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Appendix A
Nine Key Elements Critical to a Watershed Management Plan

a. An identification of the causes and sources or groups of similar sources that will need to be controlled to achieve the load reductions estimated in this watershed-based plan (and to achieve any other watershed goals identified in the watershed-based plan, as discussed in item (b) immediately below. Sources that need to be controlled should be identified at the significant subcategory level with estimates of the extent to which they are present in the watershed (e.g., X number of dairy cattle feedlots needing upgrading, including a rough estimate of the number of cattle per facility; Y acres of row crops needing improved nutrient management or sediment control; or Z linear miles of eroded streambank needing remediation).

b. An estimate of the load reductions expected for the management measures described under paragraph (c) below (recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time). Estimates should be provided at the same level as in item (a) above (e.g., the total load reduction expected for dairy cattle feedlots; row crops; or eroded streambanks).

c. A description of the nonpoint source management measures that will need to be implemented to achieve the load reductions estimated under paragraph (b) above (as well as to achieve other watershed goals identified in this watershed-based plan), and an identification (using a map or a description) of the critical areas in which those measures will be needed to implement this plan.

d. An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon, to implement this plan. As sources of funding, States should consider the use of their Section 319 programs, State Revolving Funds, U.S. Department of Agriculture’s Environmental Quality Incentives Program and Conservation Reserve Program, and other relevant Federal, State, local and private funds that may be available to assist in implementing this plan.

e. An information/education component that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be implemented.

f. A schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious.

g. A description of interim, measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.

h. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made towards attaining water quality standards and, if not, the criteria for determining whether this watershed-based plan needs to be revised or, if a nonpoint source TMDL has been established, whether the nonpoint source TMDL needs to be revised.

i. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above.

Appendix B

Load Duration Curves and Allocation Tables for Center Creek Watershed

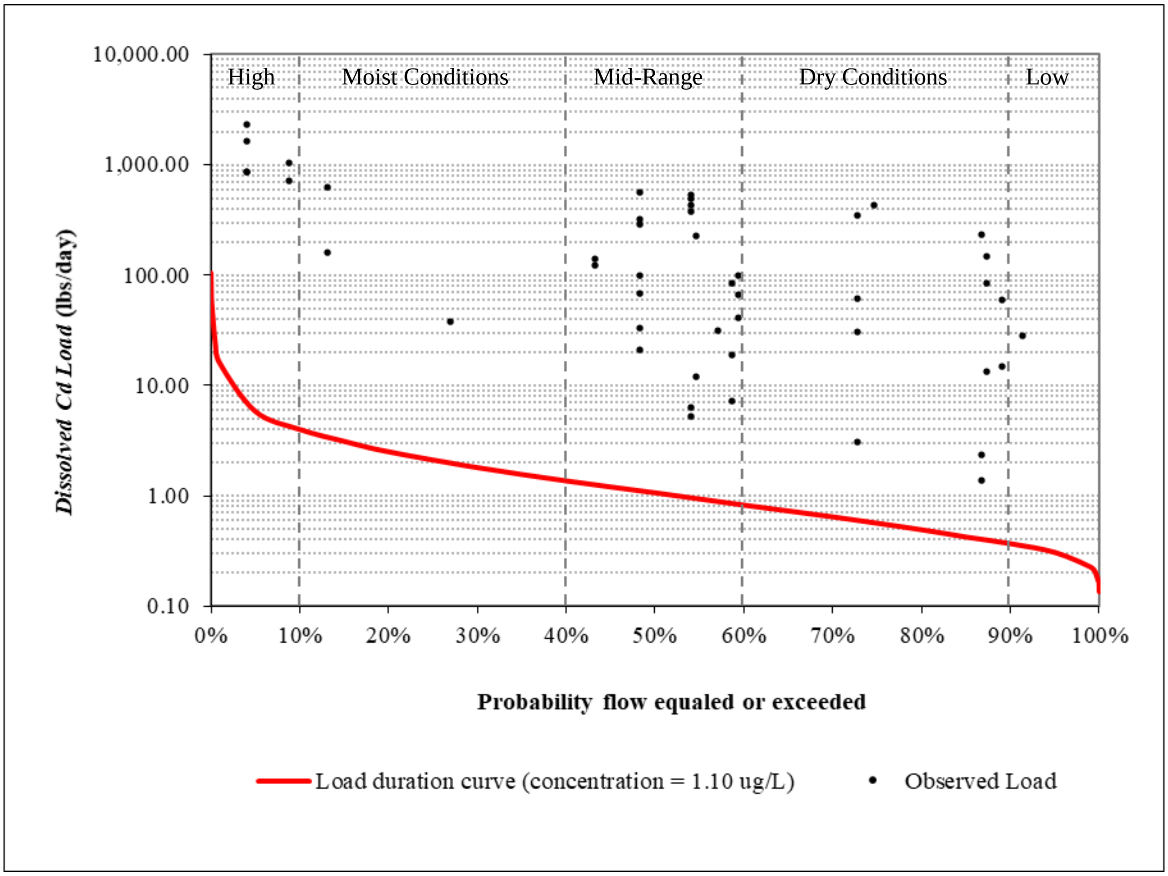

Figure 1B. Dissolved cadmium load duration curve for Center Creek, water body ID 3203.

Table 1B. Targeted dissolved cadmium reductions for Center Creek at selected flows.

Percent of time flow equaled or exceeded	Flow ft^3/s (m^3/s)	TMDL (pounds/day)	Maximum Observed Load (pounds/day)	Targeted Load Reductions (pounds/day)
95	51.4 (1.46)	0.30	28.52	28.22
75	95.7 (2.71)	0.57	437.16	436.59
50	178.6 (5.06)	1.06	558.78	557.72
25	353.6 (10.01)	2.10	635.32	633.22
5	979.4 (27.73)	5.81	2330.38	2324.57

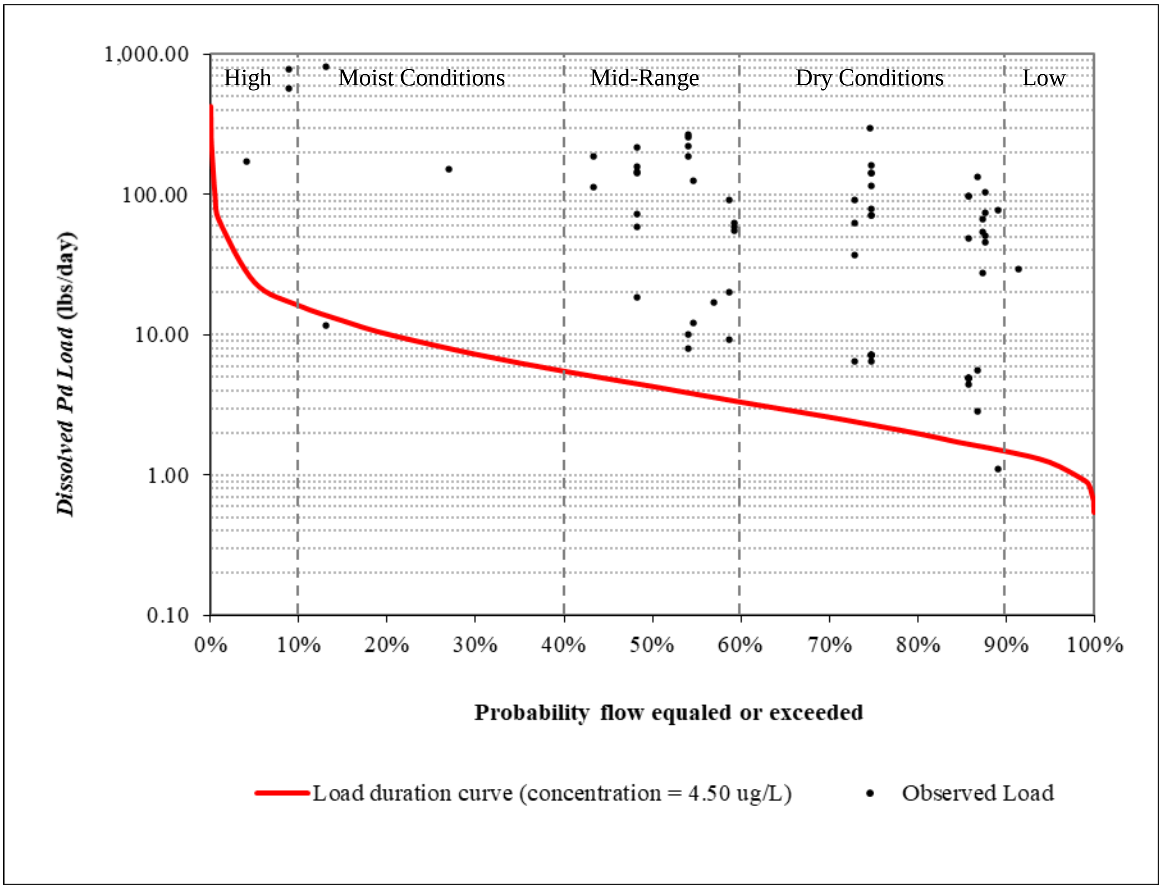

Figure 2B. Dissolved lead load duration curve for Center Creek, water body ID 3203.

Table 2B. Dissolved lead targeted reductions for Center Creek at selected flows.

Percent of time flow equaled or exceeded	Flow ft^3/s (m^3/s)	TMDL (pounds/day)	Maximum Observed Load (pounds/day)	Targeted Load Reductions (pounds/day)
95	51.4 (1.46)	1.25	29.28	28.03
75	95.7 (2.71)	2.32	299.78	297.46
50	178.6 (5.06)	4.33	259.21	254.88
25	353.6 (10.01)	8.58	815.42	806.84
5	979.4 (27.73)	23.77	788.53	764.76

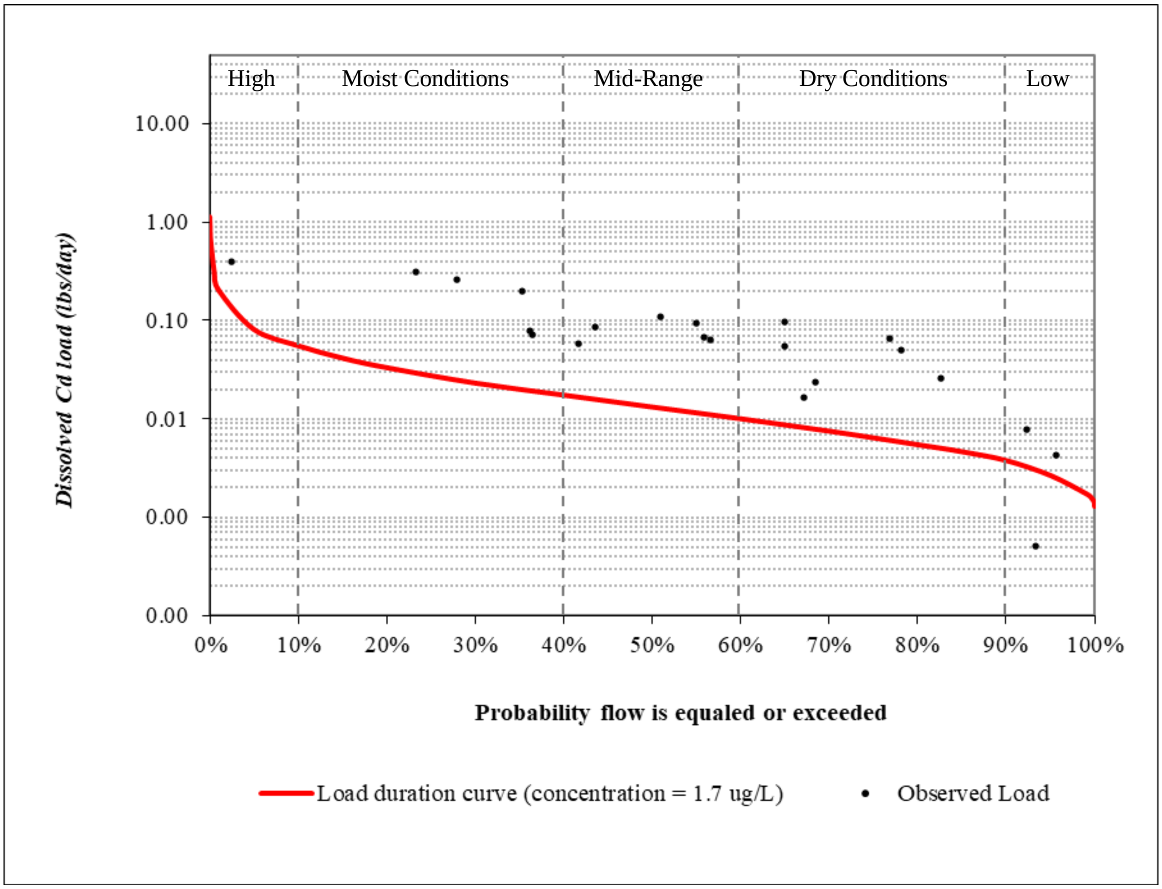

Figure 3B. Dissolved cadmium load duration curve for Center Creek Tributary, water body ID 5003.

Table 3B. Dissolved cadmium target reductions for Center Creek Tributary (WBID 5003) at selected flows.

Percent of time flow equaled or exceeded	Flow ft^3/s (m^3/s)	TMDL (pounds/day)	Maximum Observed Load (pounds/day)	Targeted Load Reductions (pounds/day)
95	0.3 (0.008)	0.003	0.008	0.005
75	0.7 (0.020)	0.006	0.097	0.091
50	1.4 (0.040)	0.013	0.110	0.097
25	3.0 (0.085)	0.027	0.308	0.281
5	8.8 (0.250)	0.081	0.392	0.311

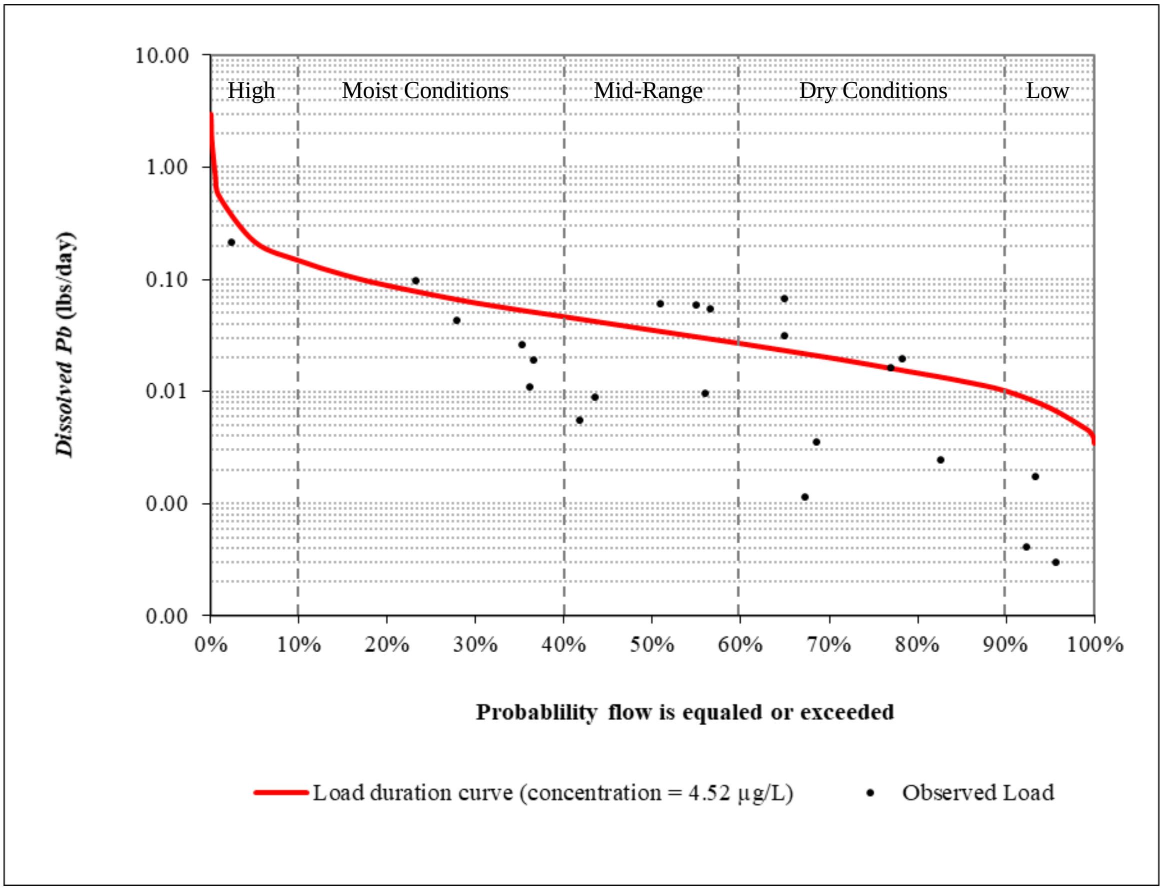

Figure 4B. Dissolved lead load duration curve for Center Creek Tributary, water body ID 5003.

Table 4B. Dissolved lead targeted reductions for Center Creek Tributary (WBID 5003) at selected flows.

Percent of time flow equaled or exceeded	Flow ft^3/s (m^3/s)	TMDL (pounds/day)	Maximum Observed Load (pounds/day)	Targeted Load Reductions (pounds/day)
95	0.3 (0.008)	0.007	0.0017	N/A
75	0.7 (0.020)	0.017	0.0671	0.0501
50	1.4 (0.040)	0.035	0.0607	0.0257
25	3.0 (0.085)	0.073	0.0979	0.0249
5	8.8 (0.250)	0.214	0.2137	N/A

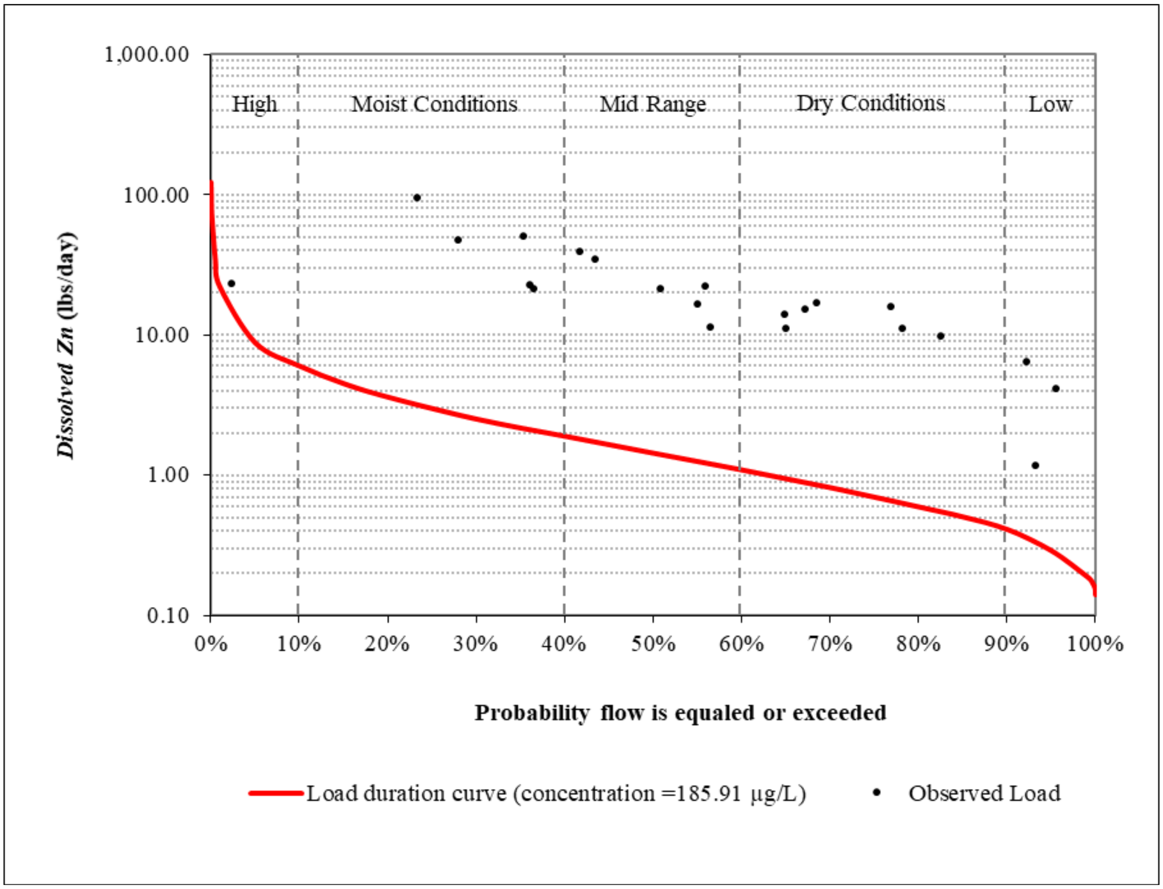

Figure 5B. Dissolved zinc load duration curve for Center Creek Tributary, water body ID 5003.

Table 5B. Dissolved zinc target reductions for Center Creek Tributary (WBID 5003) at selected flows.

Percent of time flow equaled or exceeded	Flow ft^3/s (m^3/s)	TMDL (pounds/day)	Maximum Observed Load (pounds/day)	Targeted Load Reductions (pounds/day)
95	0.3 (0.008)	0.29	6.38	6.09
75	0.7 (0.020)	0.70	16.80	16.10
50	1.4 (0.040)	1.44	39.40	37.96
25	3.0 (0.085)	3.00	94.87	91.87
5	8.8 (0.250)	8.81	23.23	14.42

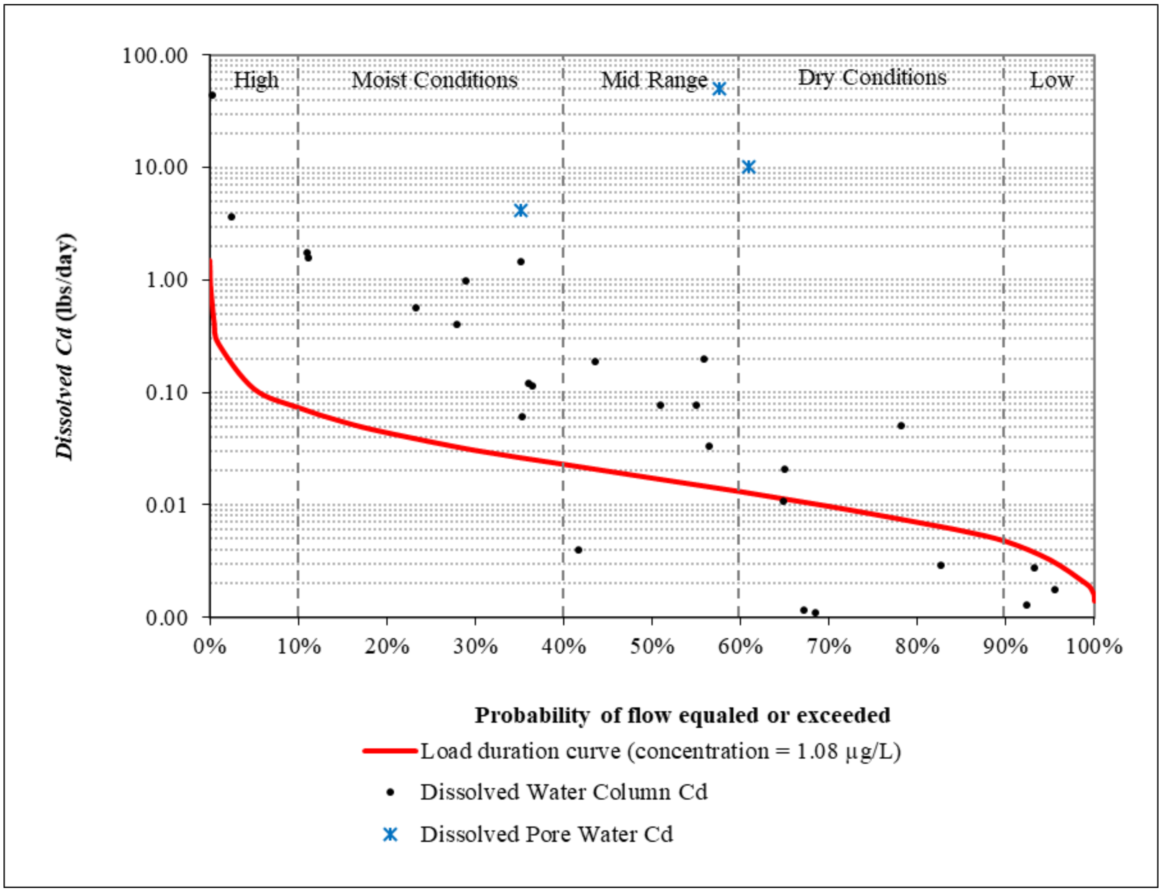

Figure 6B. Dissolved cadmium load duration curve for Bens Branch, water body ID 3980.

Table 6B. Dissolved cadmium targeted reductions for Bens Branch (WBID 3980) at selected flows.

Percent of time flow equaled or exceeded	Flow ft^3/s (m^3/s)	TMDL (pounds/day)	Maximum Observed Load (pounds/day)	Targeted Load Reductions (pounds/day)
95	0.6 (0.017)	0.01	0.003	N/A
75	1.4 (0.040)	0.02	10.26	10.24
50	3.0 (0.085)	0.04	50.33	50.29
25	6.3 (0.178)	0.08	4.11	4.03
5	18.5 (0.524)	0.23	43.63	43.40

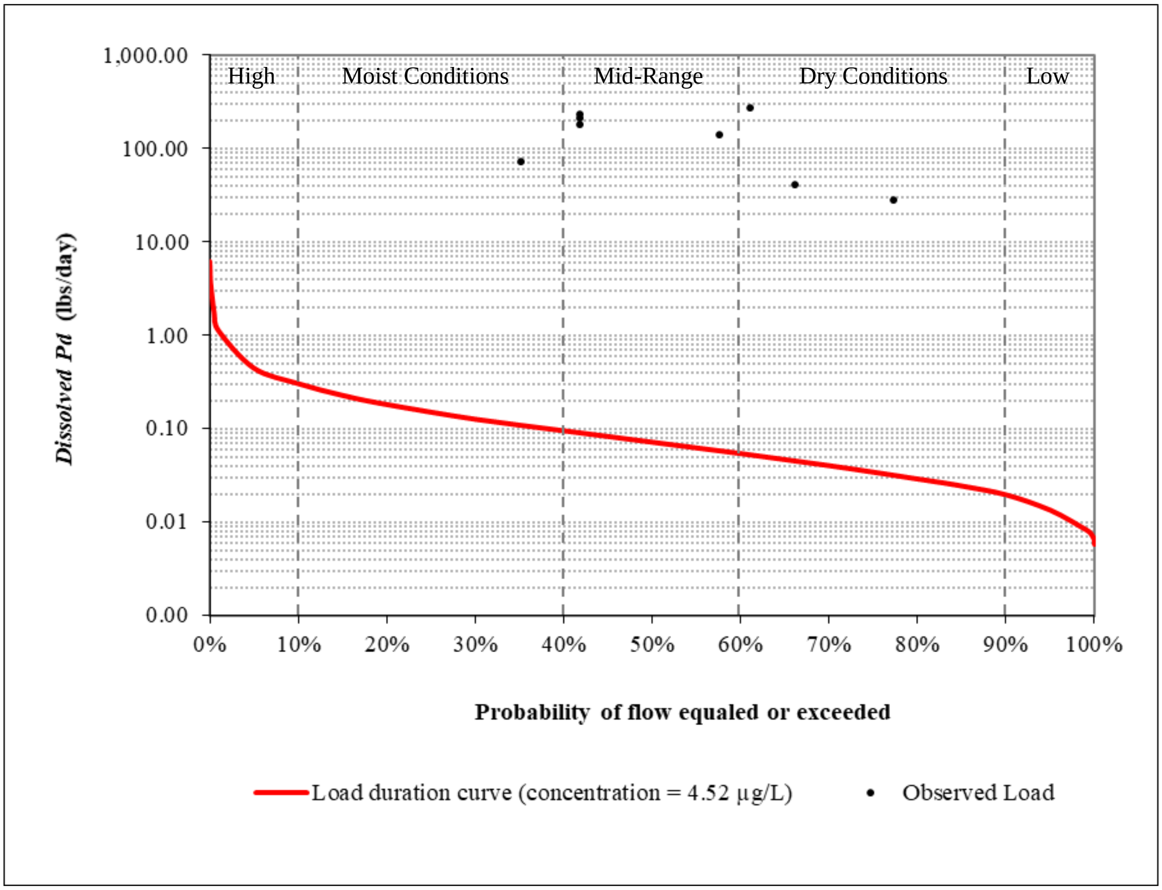

Figure 7B. Dissolved lead load duration curve for Bens Branch, water body ID 3980.

Table 7B. Dissolved lead target reduction values for Bens Branch (WBID 3980) at selected flows.

Percent of time flow equaled or exceeded	Flow ft^3/s (m^3/s)	TMDL (pounds/day)	Maximum Observed Load (pounds/day)	Targeted Load Reductions (pounds/day)
95	0.6 (0.017)	0.01	N/A	N/A
75	1.4 (0.040)	0.03	247.25	247.22
50	3.0 (0.085)	0.07	230.91	230.84
25	6.3 (0.178)	0.15	71.94	71.79
5	18.5 (0.524)	0.45	N/A	N/A

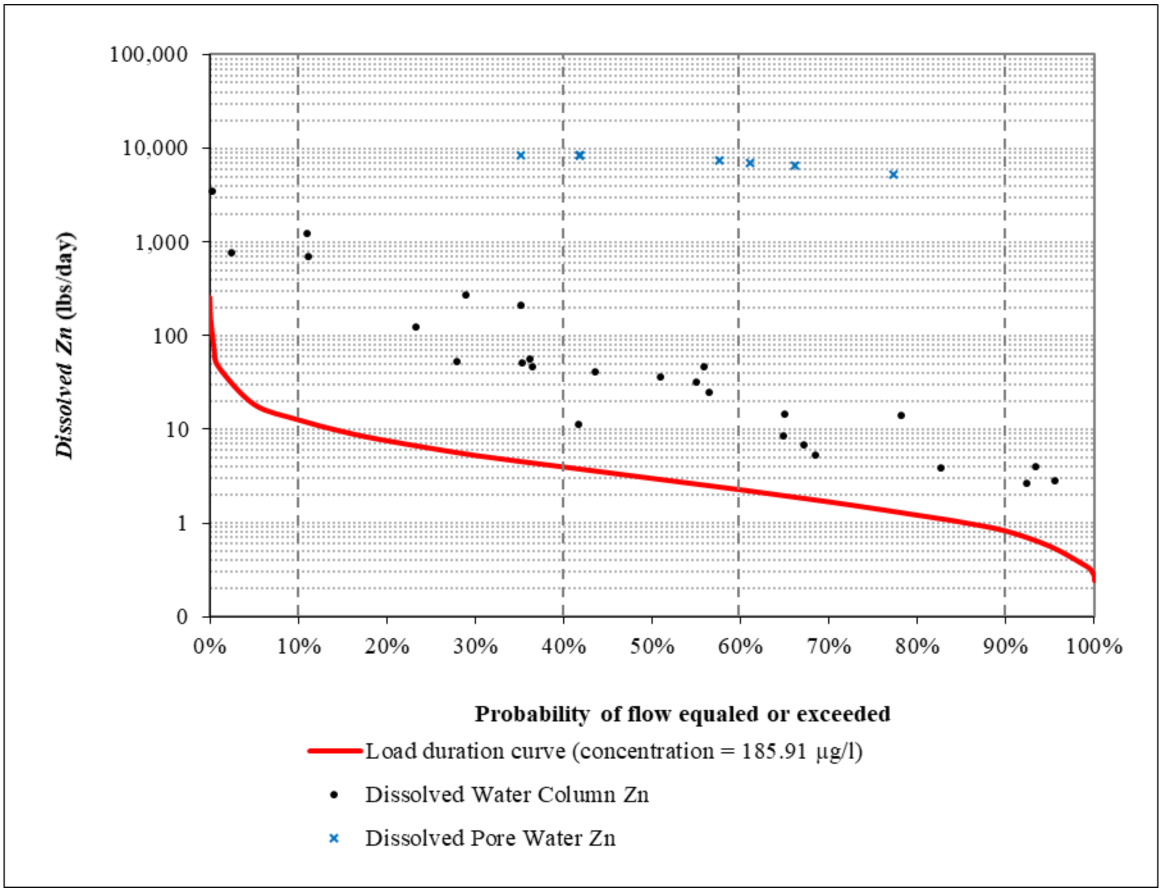

Figure 8B. Dissolved zinc load duration curve for Bens Branch, water body ID 3980.

Table 8B. Dissolved zinc target reduction values for Bens Branch (WBID 3980) at selected flows.

Percent of time flow equaled or exceeded	Flow ft^3/s (m^3/s)	TMDL (pounds/day)	Maximum Observed Load (pounds/day)	Targeted Load Reductions (pounds/day)
95	0.6 (0.017)	0.45	3.97	3.52
75	1.4 (0.040)	1.14	7,035.01	7,033.87
50	3.0 (0.085)	2.39	8,379.68	8,377.29
25	6.3 (0.178)	5.01	8,461.74	8,456.73
5	18.5 (0.524)	14.81	3,537.72	3,522.91

Appendix C

Table 1C. Dissolved cadmium wasteload allocations (pounds/day) for MS4 permitted entities in the Center Creek (WBID 3203) catchment.

Percent of time flow equaled or exceeded	Flow ft3/s (m3/s)	Total MS4	Carl Junction	Carterville	Carthage	Joplin
95	51.4 (1.46)	0.03	0.004	0.002	0.003	0.002
75	95.7 (2.71)	0.05	0.008	0.004	0.007	0.005
50	178.6 (5.06)	0.10	0.016	0.008	0.014	0.009
25	353.6 (10.01)	0.21	0.033	0.016	0.029	0.019
5	979.4 (27.73)	0.59	0.092	0.044	0.082	0.054

Percent of time flow equaled or exceeded	Flow ft3/s (m3/s)	Oronogo	Jasper Co.	Webb City	MoDOT
95	51.4 (1.46)	0.002	0.004	0.006	0.001
75	95.7 (2.71)	0.004	0.009	0.013	0.002
50	178.6 (5.06)	0.008	0.018	0.025	0.004
25	353.6 (10.01)	0.017	0.037	0.050	0.007
5	979.4 (27.73)	0.047	0.104	0.142	0.021

Table 2C. Dissolved lead wasteload allocations (pounds/day) for MS4 permitted entities in the Center Creek (WBID 3203) catchment.

Percent of time flow equaled or exceeded	Flow ft3/s (m3/s)	Total MS4	Carl Junction	Carterville	Carthage	Joplin
95	51.4 (1.46)	0.10	0.016	0.008	0.014	0.009
75	95.7 (2.71)	0.21	0.033	0.016	0.030	0.020
50	178.6 (5.06)	0.42	0.066	0.032	0.058	0.038
25	353.6 (10.01)	0.85	0.134	0.064	0.119	0.078
5	979.4 (27.73)	2.41	0.377	0.182	0.335	0.221

Percent of time flow equaled or exceeded	Flow ft3/s (m3/s)	Oronogo	Jasper Co.	Webb City	MoDOT
95	51.4 (1.46)	0.008	0.018	0.025	0.004
75	95.7 (2.71)	0.017	0.038	0.052	0.008
50	178.6 (5.06)	0.033	0.075	0.102	0.015
25	353.6 (10.01)	0.068	0.152	0.207	0.030
5	979.4 (27.73)	0.192	0.429	0.584	0.086

Table 3C. Dissolved cadmium wasteload allocations (pounds/day) for MS4 permitted entities in the Tributary to Center Creek (WBID 5003) catchment.

Percent of time flow equaled or exceeded	Flow ft3/s (m3/s)	Total MS4	Oronogo
95	0.3 (0.008)	0.0001	0.0001
75	0.7 (0.020)	0.0004	0.0004
50	1.4 (0.040)	0.0008	0.0008
25	3.0 (0.085)	0.0017	0.0017
5	8.8 (0.250)	0.0052	0.0052

Table 4C. Dissolved (water column) lead wasteload allocations (pounds/day) for MS4 permitted entities in the Tributary to Center Creek (WBID 5003) catchment.

Percent of time flow equaled or exceeded	Flow ft3/s (m3/s)	Total MS4	Oronogo
95	0.3 (0.008)	0.001	0.001
75	0.7 (0.020)	0.002	0.002
50	1.4 (0.040)	0.003	0.003
25	3.0 (0.085)	0.007	0.007
5	8.8 (0.250)	0.022	0.022

Table 5C. Dissolved (water column) zinc wasteload allocations (pounds/day) for MS4 permitted entities in the Tributary to Center Creek (WBID 5003) catchment.

Percent of time flow equaled or exceeded	Flow ft3/s (m3/s)	Total MS4	Oronogo
95	0.3 (0.008)	0.02	0.02
75	0.7 (0.020)	0.07	0.07
50	1.4 (0.040)	0.14	0.14
25	3.0 (0.085)	0.30	0.30
5	8.8 (0.250)	0.89	0.89

Table 6C. Dissolved cadmium wasteload allocations (pounds/day) for MS4 permitted entities in the Bens Branch (WBID 3980) catchment.

Percent of time flow equaled or exceeded	Flow ft3/s (m3/s)	Total MS4	Carterville	Joplin	Webb City	MoDOT
95	0.6 (0.017)	0.00030	0.00012	0.000005	0.00015	0.00003
75	1.4 (0.040)	0.00081	0.00031	0.000013	0.00040	0.00008
50	3.0 (0.085)	0.00174	0.00067	0.000029	0.00086	0.00018
25	6.3 (0.178)	0.00368	0.00142	0.000061	0.00181	0.00038
5	18.5 (0.524)	0.01095	0.00423	0.000181	0.00540	0.00114

Table 7C. Dissolved lead wasteload allocations (pounds/day) for MS4 permitted entities in the Bens Branch (WBID 3980) catchment.

Percent of time flow equaled or exceeded	Flow ft3/s (m3/s)	Total MS4	Carterville	Joplin	Webb City	MoDOT
95	0.6 (0.017)	0.00125	0.00048	0.00002	0.00062	0.00013
75	1.4 (0.040)	0.00339	0.00131	0.00006	0.00167	0.00035
50	3.0 (0.085)	0.00726	0.00281	0.00012	0.00358	0.00076
25	6.3 (0.178)	0.01541	0.00596	0.00025	0.00760	0.00161
5	18.5 (0.524)	0.04582	0.01771	0.00076	0.02258	0.00478

Table 8C. Dissolved zinc wasteload allocations (pounds/day) for MS4 permitted entities in the Bens Branch (WBID 3980) catchment.

Percent of time flow equaled or exceeded	Flow ft3/s (m3/s)	Total MS4	Carterville	Joplin	Webb City	MoDOT
95	0.6 (0.017)	0.05139	0.01986	0.00085	0.02533	0.00536
75	1.4 (0.040)	0.13962	0.05396	0.00230	0.06881	0.01455
50	3.0 (0.085)	0.29879	0.11547	0.00493	0.14726	0.03114
25	6.3 (0.178)	0.63389	0.24497	0.01046	0.31240	0.06606
5	18.5 (0.524)	1.88479	0.72838	0.03110	0.92889	0.19642